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BRIEFER ARTICLES

LONGEVITY OF SEEDS

In a recent article on longevity of seeds, EWART[1] makes a number of statements which merit comment. He assumes as correct the claim of BERGTHEIL and DAY[2] (working on *Indigofera arrecta*) that they have priority in discovering that the water-resisting power of the seeds of legumes is due to the character of an outer layer of the coat. NOBBE,[3] however, pointed out the fact for *Trifolium pratense* 31 years before the publication by BERGTHEIL and DAY. Both find that stains dissolved in water penetrate in the hard seeds only through the very thin outer layer, called cuticle by NOBBE; but that they do not pass through the palisade layer. This is shown in *fig. 1* of BERGTHEIL and DAY'S article. EWART finds the resistance in *Adansonia digitata* to be due to the impermeable nature of all layers of the integument, and I find the same to be true of the hard seed of *Axyris amaranthoides*. It is generally assumed that in the Leguminosae the impermeability to water is never due to oily deposits. I find that the seed of the mesquite (*Prosopis juliflora*) is an exception. By soaking these seeds in ether for several days and then allowing the ether to evaporate, a large percentage is caused to germinate when germinative conditions are supplied, while a direct supply of germinative conditions brings only 5 to 10 per cent. The evaporation of the ether in which they have been steeped always shows an oily residue. Absolute alcohol is less effective in this case.

EWART says: "The seeds of the hawthorn are supposed not to germinate until after a year in the ground. CROCKER obtained no definite confirmation or negation of this fact, but here also it appears to be a case of the slow disintegration of the seed coats." This is hardly consistent with the statement (p. 284) in my paper on the rôle of seed coats.[4] In this case, however, I have underestimated the significance of the coats. I find that in *Crataegus mollis* embryos taken from apples just ripe and entirely freed from the two coats and endosperm begin growth within a few days after being

[1] EWART, A. L., On the longevity of seeds. Reprint Proc. Roy. Soc. Victoria N. S. **21**. pp. 210. 1908.

[2] BERGTHEIL, C., and DAY, D. L., On cause of "hardness" in seeds of *Indigofera arrecta*. Annals of Botany **21**:57–60. 1907.

[3] NOBBE, F., Handbuch der Samenkunde 117. 1876.

[4] CROCKER, WM., Rôle of seed coats in delayed germination. BOT. GAZETTE **42**:265–291. 1906.

put into the germinator, whether in light or dark. The removal of the inner coat and endosperm is done after sterilization, and the whole process, including germination, is conducted under aseptic conditions. One finds this a very tedious task and the resulting germination is of a peculiar type. In the light the cotyledons begin to expand and turn green. A small percentage of the roots begin growth within a week, but in a larger percentage the roots begin growth only after several weeks and after the cotyledons have expanded to several times their original size. Many of the radicles do not grow even after two months in the germinator. In the dark the growth is similar except that the cotyledons turn yellow and the radicles are even more tardy in their development. The coats then seem to play an important part in the delay, but the tardiness of the radicle in its development is of especial interest and reminds one of the behavior of the fungus-free orchid seeds,[5] or the upper seeds of the cocklebur with coats intact and in 76^{cm} of oxygen pressure.[4] A full investigation of the physiology of the germination of these seeds is now in progress by Mr. W. E. DAVIS and myself.

EWART again says: "CROCKER has, however, overlooked the fact that both the early and late seeds of *Xanthium echinatum* will germinate at 20 to 25° C. if the temperature is maintained for fourteen to twenty-one or more days instead of for eight to nine days." I assume that EWART means with coats intact, for that is the connection in which I have made my statement. On November 5, 1908, burs of this species were collected from the plants, the seeds removed from the burs, and the upper seeds soaked 18 hours, so as to show up any defective coats. Upper seeds with perfect coats were placed between wet filters in baths; one maintained at 24–25°, and one at 27–28°. On December 5 none had germinated. Of course with coats removed these seeds germinate within three days, even at 23°. In collections of this species from the crop of 1906 a small percentage of the upper seed with coats intact germinated at 30°. In collections of the crop of 1905, on which the work for my paper was done, the minimum temperature for the germination of these upper seeds lay between 32° and 33° even when they were kept in the germinator for a month. EWART says nothing about the time of gathering, precautions against defective coats, or the percentage germinating at 20–25°. In the absence of all these related data his statement can mean little. In *X. canadense* high temperatures are far less effective in overcoming seed-coat effects, and here a temperature fluctuating between 25° and 41° is most effective. A temperature of 40–43° for a few hours is often more effective than a lower temperature for a

5 BERNARD, N., On the germination of orchids. Roy. Hort. Soc. Rep. 3rd Internat. Congress on Genetics 292–296. 1906.

much longer period, a fact that led to the discovery of the temperature effects. In the light of this fact, EWART's statement, "If burs are heated at 40° C. for a day or two, 50° for a few hours during soaking, a variable percentage of the later seeds will germinate within ten days," is not at all new. My data have shown that the effectiveness of high temperatures in overcoming seed-coat effects varies greatly with different species. Further, my data indicate that there is in this respect a slight variation in different crops of the same species gathered from the same locality, and it appears, if EWART's data have been obtained with proper attention to sources of error, that there is a decided variation in seeds gathered from different regions of the globe.

EWART's assumption that the coats in the seeds of water plants secure this delay by excluding oxygen does not seem to be true for some of these species. I have mentioned evidence for this in the case of the water hyacinth.[6] One of our students, working with the effects of oxygen on germination, tells me that seeds of *Alisma Plantago* germinate rather readily in entire absence of oxygen, provided the coats are ruptured. In the case of the upper seeds of *X. canadense* she finds that about 3^{cm} of oxygen pressure (0.2 that of the ordinary atmosphere) with two weeks' exposure is necessary to produce germination, even when the coats are removed. These results still need to be thoroughly tested. TAKAHASHI[7] has shown that seeds of rice germinate in entire absence of oxygen. It is probable, therefore, that the coats of the seeds of water plants secure delay in germination mainly by limiting the water supply, as I have pointed out.[6]

Through a discussion of minor and less significant details, however, we must not lose sight of the main conclusion, which is being more firmly established as more data are accumulated,[8] that delayed germination in seeds is generally, though not always, related to seed-coat characters rather than to so-called dormancy of protoplasm. The coat may limit the oxygen supply, as in the cocklebur; it may exclude or merely limit the water supply, as in the seeds of legumes on the one hand and of Iris and other water plants on the other; or it is possible, though not proved, that in some cases it may exclude other chemical compounds necessary for germination.

I believe I am doing EWART no injustice when I say that it is impossible to tell from his paper in how far it is a contribution and in how far a

[6] CROCKER, WM., Germination of the seeds of water plants. BOT. GAZETTE **44**: 375–380. 1907.

[7] TAKAHASHI, T., Is germination possible in absence of air? Bull. Coll. Agr. Tokyo **6**:439–442. 1905.

[8] KLUGH, G. F., Some cases of delayed germination in seeds. Science N. S. **28**:816. 1908.

compilation. In this way credit due other investigators appears to belong to EWART, and no one has suffered more in this respect than the writer.—WILLIAM CROCKER, *The University of Chicago.*

RESPIRATION CALORIMETER

On p. 133 of the second edition of Professor W. F. GANONG'S admirable *Laboratory course in plant physiology*, which has just appeared, and a copy of which has come into my hands through his courtesy, I am interested to find a Dewar flask figured as a respiration calorimeter. Before my recent paper was published (BOT. GAZETTE **46**:193–202. 1908), I wrote to Mr. GANONG, knowing that he was preparing a second edition of his book, asking him to put my calorimeter into it. He wrote that his book had already gone to press. When my paper appeared he wrote again, saying that he "had been using the Dewar bulbs as a respiration calorimeter some four years past. . . . . Of course the point about the prior use of the bulbs is of no consequence whatever, and I mention it now because of the coincidence in your asking me to mention their use in my book."

So far as priority of use is concerned, it lies obviously with Mr. GANONG. To acknowledge this, and to record another of the curious coincidences which after all are not altogether rare in the history of science, is the purpose of this note.—GEORGE J. PEIRCE, *Leland Stanford Junior University.*

CRATAEGUS IN COLORADO

The attention of the writer has been called by Mr. W. W. EGGLESTON to a misstatement in an article in this journal for November, 1908. On p. 382, line 4, I should have said that the species described resembles most *C. erythropoda*, of the forms known to the writer in northern Colorado.—FRANCIS RAMALEY, *Boulder, Colorado.*